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Control Of Ink-Water-Balance Using Ultrasonic Sensors

by Gunter Huebner and Karl R. Scheuter

Introduction

In recent years control systems have become more and more important in industrial production. Accordingly, for offset printing the present state of the art is to control the ink feed off-line by measuring the optical density of full tone bars on the printed sheets. Gradually the off-line versions are being substituted by closed loop controlling devices which use in-line press densitometers. However the control of the second fundamental component, the fountain solution has not yet reached a satisfactory standard. Recent developments, especially from Japan have been trying to change this unsatisfactory state.

All of the known fountain solution control systems use the same physical principle, i. e. they detect the intensity of an infrared light beam which is reflected by the non image areas of the printing plate. This intensity depends on the amount of water on the plate's surface, because water molecules absorb infrared light at certain wavelengths. The disadvantages of this method are the strong dependence on the surface properties of the substrate (non image areas) and the rather complicated and accordingly large and expensive analyzer units. Additionally, cooling of the IR-sensors is necessary. In 1981, during research work dealing with the influence of the water concentration in the ink on the splitting behaviour, it was found that the noise which is emitted by the splitting of the ink-water-mixture at the outlet of the nip of two rollers is strongly correlated to the ink-water-balance. The qualitative behaviour of the sound level detected by a microphone versus the ink-water-ratio is plotted in fig. 1. The sound level signal increases either with increasing ink feed or decreasing water feed:

this may lead to scumming. On the other hand the sound level sinks with decreasing ink feed or increasing water feed: this, in the extreme, may be accompanied by water marks. Therefore, if only one microphone is used, it is obviously not possible to decide which one of the two components, the ink or the water, is responsible for the change in signal level.

Frequency Analysis

To obtain the maximum information about the splitting sound a frequency analysis of the microphone signals was carried out at the beginning of our studies. It was found, that

- the ink splitting sound is similar to a random noise
- the main quota of the sound energy distribution lies in the ultrasonic range (> 20 kHz) and only a small quota in the audible range
- changing printing conditions (e.g. water feed, ink feed, printing speed etc.) will only cause a change in signal intensity but not in the frequency spectrum
- in a running press there are no other machine sound sources in the ultrasonic range, which may affect the measurements

According to these results it is not necessary to use wideband measuring microphones, because an excellent electronic signal for the ink-water-ratio can already be obtained by using an ultrasonic piezo microphone (with a sharp resonance at 40 kHz) in combination with the simple electronic circuit as shown in fig. 2. The most suitable type of cristal-microphone is completely enclosed by an aluminium shield which makes it quite impervious to all dirt and ink droplets, yet easy to clean if once soiled. The price for this type of microphone is about 6 $ only.

Printing Experiments

To check the usefulness of the ultrasonic signals for the purpose of constructing an ink-water-balance controlling system, a sheet fed press was equipped with 10 cristal-microphones, as shown in fig. 3. Already the first experiments demonstrated that it is sufficient and conclusive to observe the signals of only two microphones. Hereafter they will be named M_W ("water microphone") and M_I ("ink microphone"). M_W is located near the dampening unit and observes the water feed, whereas M_I is placed near the ink ductor and acts as an ink feed reference. Fig. 4 shows some typical curves of the measured ultrasonic signals U_W and U_I of the microphones M_W and M_I. According to fig. 1 both signals become "louder" with increasing ink film thickness on the paper, which is correlated to the ink feed when no change in water feed happens (fig. 4a, b). The signal of M_W will decrease with increasing water feed when the ink feed setting is kept constant (fig. 4c). Unexpectedly M_I's signal U_I first increases when the water feed is increased from a scumming minimum value to a medium one (fig. 4d). The explanation for this is given by the results of a previous research project at IDD, where the ink film thicknesses on an inking unit during printing were measured. It was found that the water between the ink rollers hinders the ink transfer, causing an ink-accumulation and thus an increasing ink film thickness in the inking unit. Since ink flow and water flow have opposite directions, especially in the upper part of the inking units, and also owing to evaporation, there is still no water at M_I's nip, yet the increased ink film thickness causes the signal to become "louder". Only by further increasing the water feed can water reach the ink ductor, thereby causing the M_I signal to reach a maximum and finally (according to fig. 1) to decrease. This effect is only possible when a dampening unit is used which allows an excess in feeding. Further experiments with a sheet fed press equipped with an up-to-date alcohol dampening unit (fig. 5) showed that it was not possible to lower the signal of M_I even with maximum water feed setting (i. e. maximum speed of the water ductor roller). The curve in fig. 4d would then become strictly monotone.

Interpretation of Ultrasonic Signals During Printing

With these signal patterns five different cases are possible:

case	M_W	M_I	Interpretation
1	constant	constant	no change in ink-water-balance
2	increas.	increas.	increasing ink feed
3	decreas.	decreas.	decreasing ink feed
4	increas.	decreas.	decreasing water feed
5	decreas.	increas.	increasing water feed

Table 1

To verify the above results an experiment was carried out using the sheet fed press shown in fig. 5, where the press settings were manually modified (fig. 6b, c, d). Using table 1, it is very easy to interpret the resulting cross directional signal pattern in fig. 6a as changes in water feed (fig. 6d) and the parallel patterns as changes in ink feed (fig. 6c). With increasing press speed (fig. 6b) both signal levels rise but there is no change in their principal behaviour.

Suggestion for an Analyzer Unit

The absolute levels of the ultrasonic signals do not contain any significant information, because they depend on various parameters such as press speed, roller adjustment, microphone distance or ink viscosity. Thus it is only meaningful to monitor the change in the signals and not their absolute level. The best method of observation is to connect the signal U_I to the X-deflection unit of an oscilloscope screen and U_W to the Y-deflection. On the screen a single point will appear which must be adjusted to the middle of the screen after the printer has defined an optimal run on setting. Changes in ink-water-balance will now cause a wandering of that point towards the edges of the screen as shown in fig. 7. From the point's position an interpretation of occuring process irregularities can be made.

Outlook

Based on the above results, the construction of an adequate algorithm for a closed loop dampening control is now subject to further development. In order to overcome the difficulty of the non monoton slope in fig. 4d (dampening units with the possibility of overdriving) it may be of advantage to use an optical sensor for the ink film thickness instead of M_I. Our latest developments allow these optical measurements not only for special colored inks but also for the three colors of the "Europa-skala" (but not yet for black ink).

Long running tests will now have to show whether the ultrasonic method is a simple and cheap alternative to the infrared-control of offset dampening.

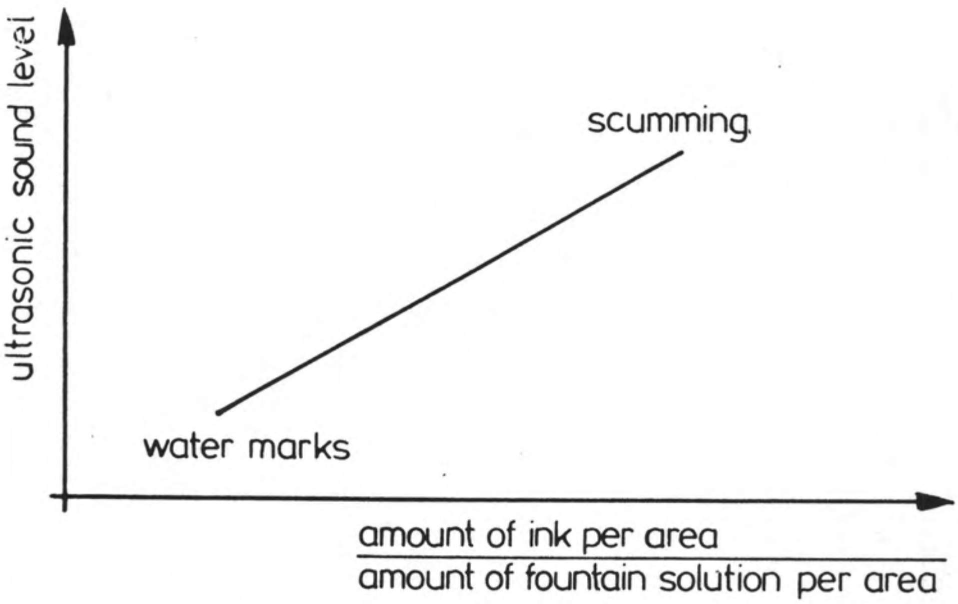

Fig. 1 Principal behaviour of the sound level versus the ink-water-ratio

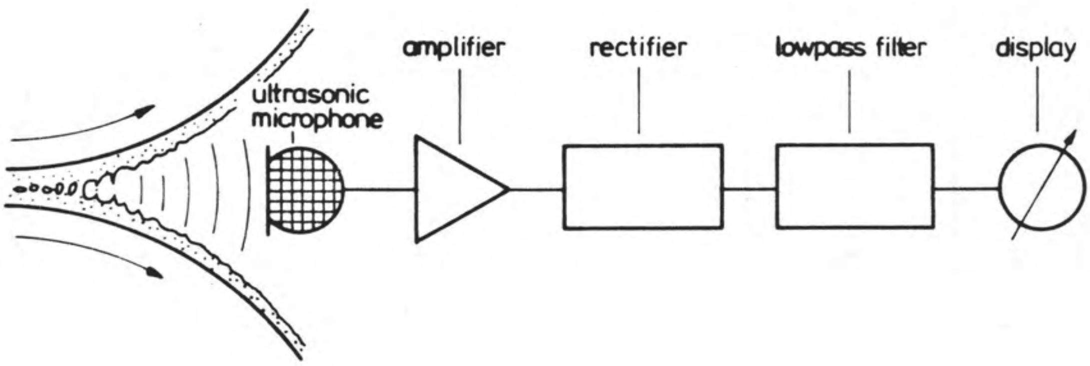

Fig. 2 Electronic circuit of the ultrasonic sensor

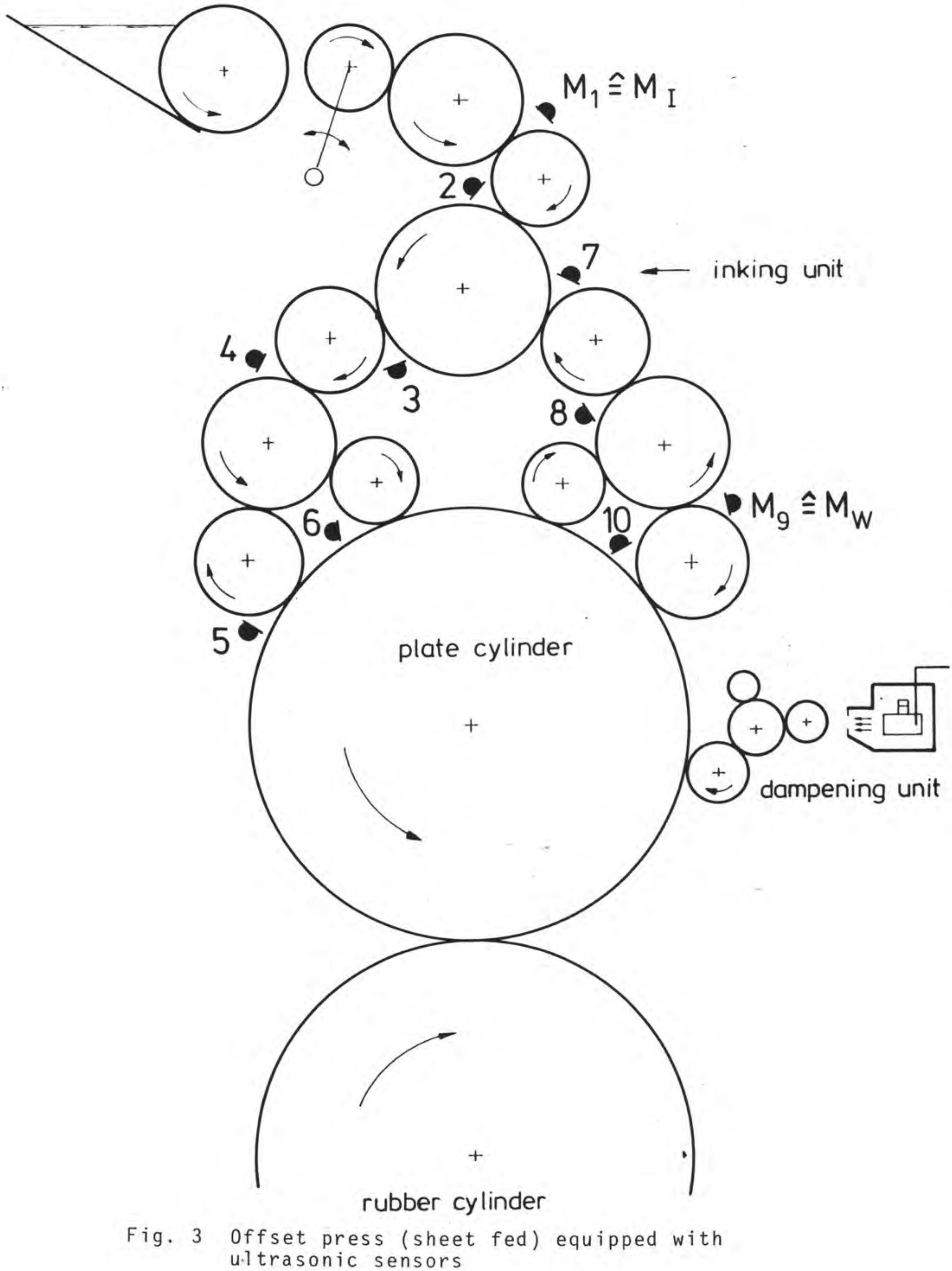

Fig. 3 Offset press (sheet fed) equipped with ultrasonic sensors

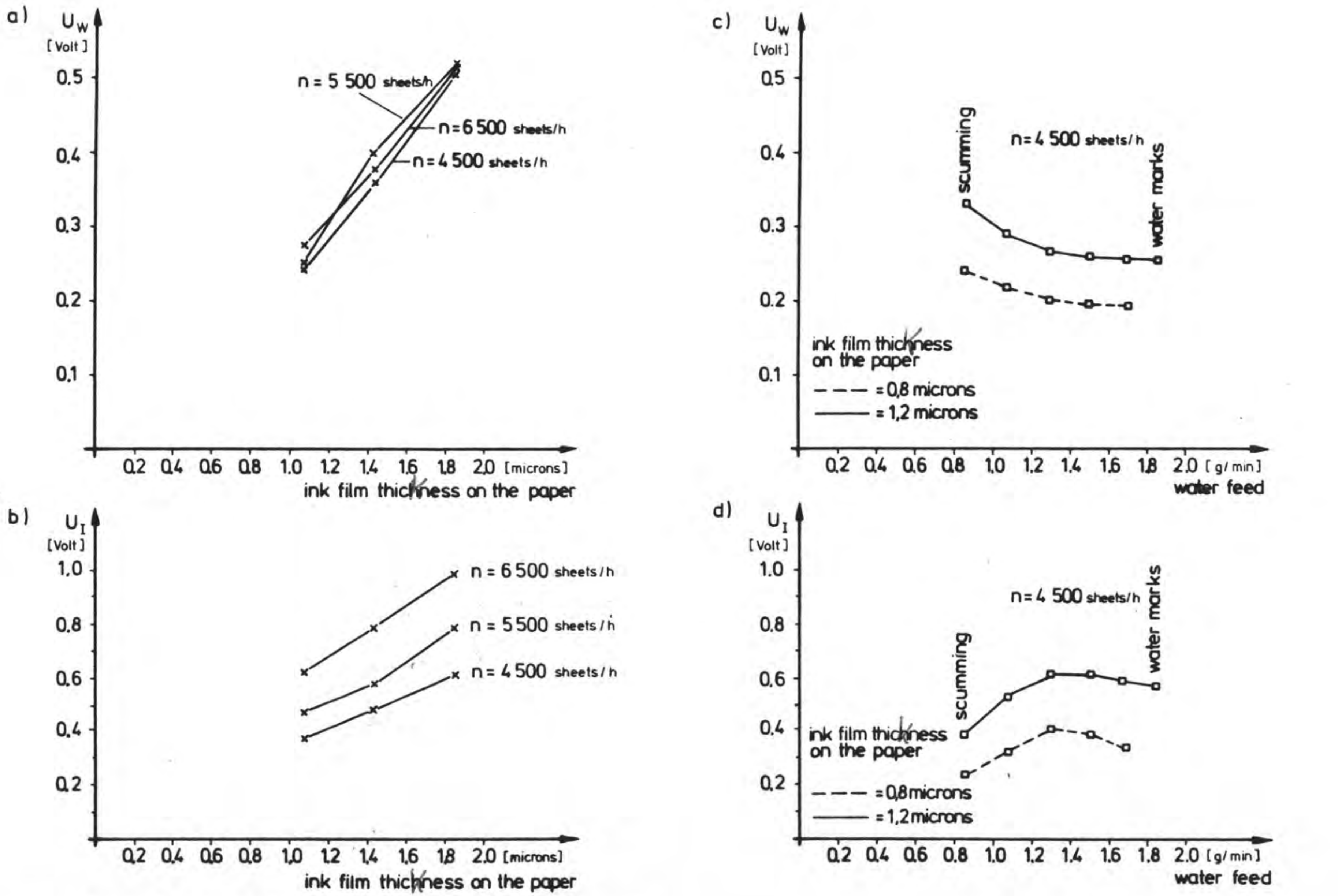

Fig. 4 Examples for the behaviour of the signals U_W and U_I with changing press settings

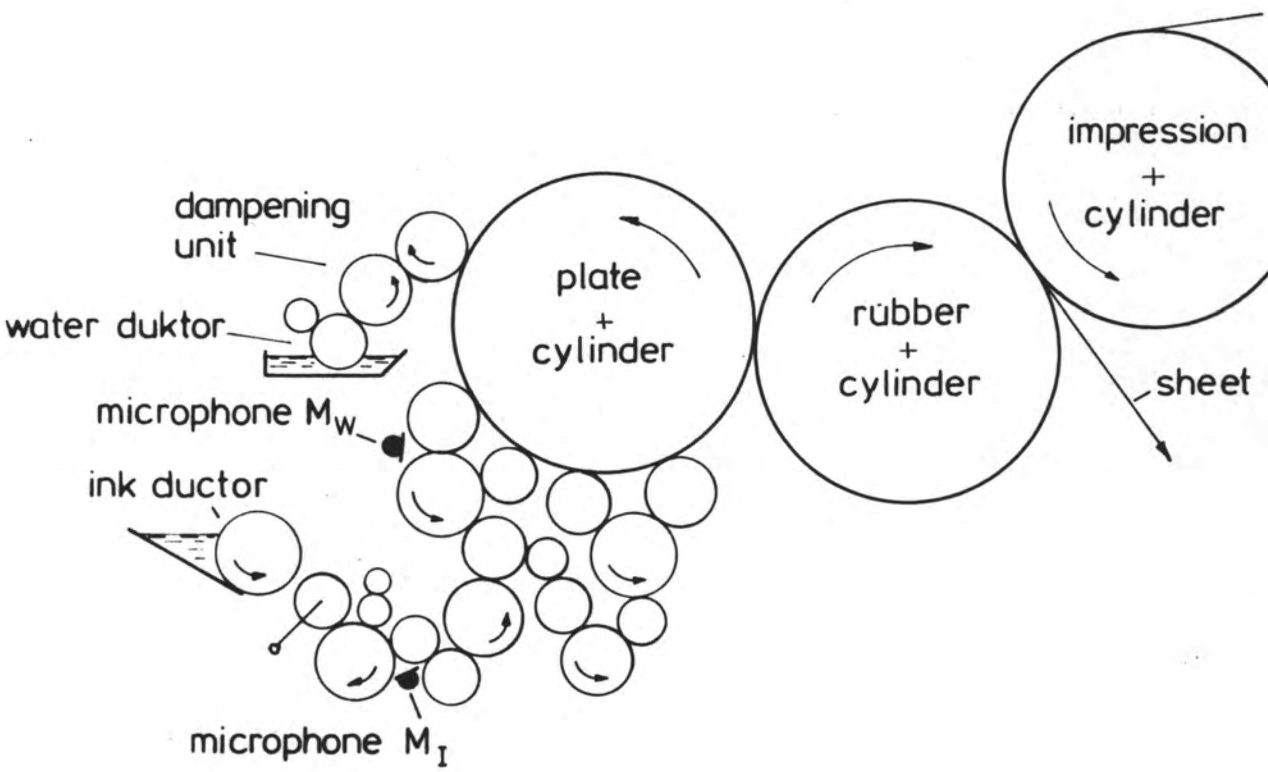

Fig. 5 Offset press with alcohol dampening unit

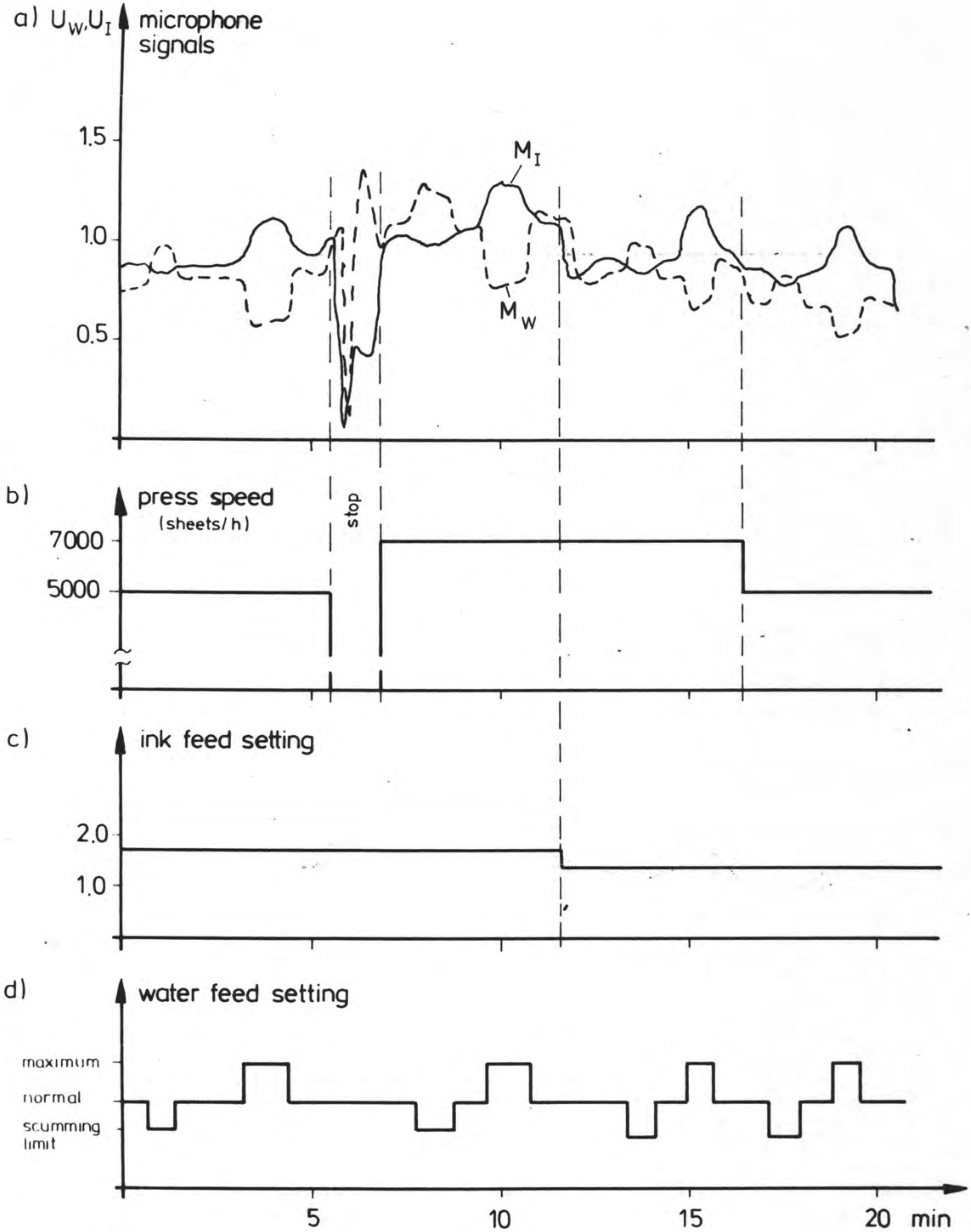

Fig. 6 Example of the signal patterns versus time with changing press settings

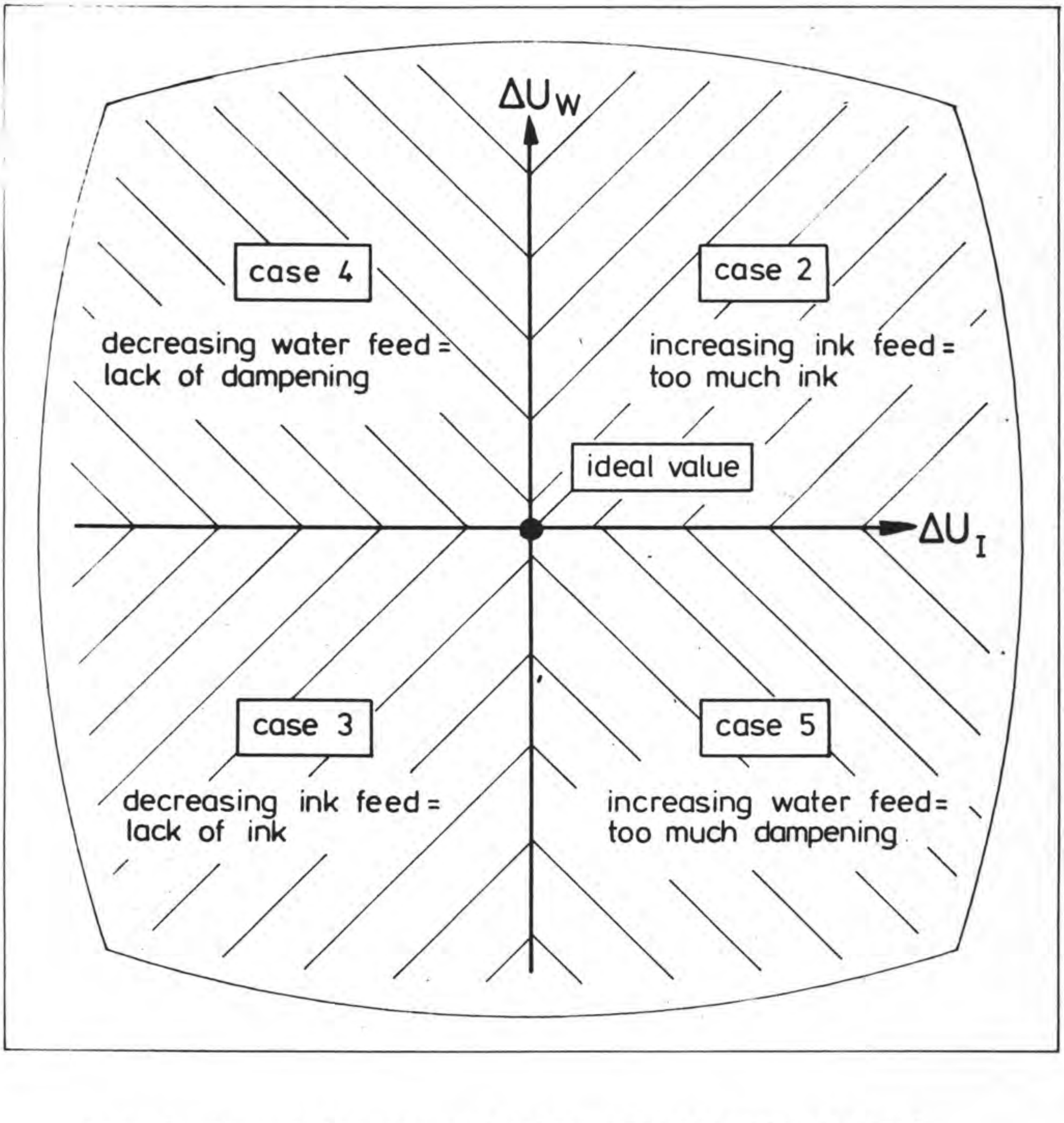

Fig. 7 Suggestion for a display (oscilloscope screen)